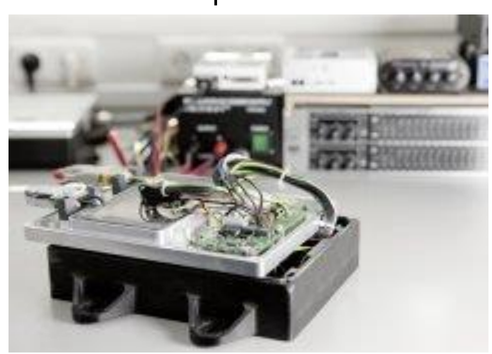
Noise Control in EVs and HEVs for Enhanced Safety and Battery Life

It goes without saying that electric vehicles are a revolutionary step in the automobile industry over petrol-vehicles because of the lower levels of carbon emissions. However, as EVs became popular society has realized that there are some problems with the low noise produced by them. Most importantly, silent vehicles can pose safety hazards to pedestrians, especially those who are elderly or hard of hearing, since there are no audio clues that a vehicle is approaching to deal with this issue, governments are developing laws that require quiet vehicles such as EVs and HEVs to use artificial sounds.

One such law has come from the National Highway Transport Safety Association (NHTSA) in the US. In a study conducted by the NHTSA, electric vehicles were found to be barely noticeable when operated at speeds lower than 6 miles an hour. This means an electric car moving in a shopping mall parking lot, through busy traffic or in a residential neighborhood can be difficult to identify increasing the likelihood of pedestrian injuries. Yet artificial sounds are estimated to lower pedestrian injuries by at least 2,790 every year.[i]

The proposed NHTSA artificial sound requirements are only applicable to the HVs and the EVs that are capable of propulsion in reverse or forward gear without using the ICE of the vehicle. Such vehicles produce less sound at low speed when compared to vehicles that operate the ICE, since there is no mechanical vibration produced by the ICE. To meet these new standards, OEMs are creating their own sound packages to help increase the safety of their EVs, HEVs, and other virtually silent vehicles.



The US isn't the only country working on legislations for soundless EVs and HEVs. Both the EU and Japan have draft legislations in the works for a minimum level of sound from electric and hybrid vehicles. In Japan, the Ministry of Land, Infrastructure, Transport and Tourism has established draft guidelines for using warning sounds similar to engine sounds which should be finalized shortly. In the EU, draft guidelines for Acoustic Vehicle Alerting Systems were established in 2011 which recommend manufacturers to install systems to provide warnings to pedestrians and other vulnerable road users. This draft guideline is currently temporary as the EU anticipates a globally harmonized device performance specification to be established eventually.[ii]

Manufacturer Response To The Noise System Requirement

e-sound control unit

AUDI's solution for the problem of their silent vehicles is AUDI e-sound, a sound generator made for their futuristic electric e-tron cars. AUDI's real time sound generator produces synthetic motor sounds for silent automobiles to warn cyclists and pedestrians.

Unlike a prerecorded sound generated when the vehicle runs, it's a real time sound produced from the car based on several factors like the rotational speed of motor, the total speed of the car, load and the size. Each model from the AUDI e-tron series has its unique sound system and is produced from a loudspeaker fixed to the undercarriage.

This sound varies from five to eight watts under normal operation, but the sound system is capable of handling up to 40 watts. Significant attempts have been made to keep this sound transfer to the interior of the vehicle to the minimal to maintain the quiet ambience that an electric car ideally promotes.

The e-sound was developed in a specialized acoustic test bed facility, which is a large room covered with thick sound absorbent walls. The room has been designed to mimic real-time outdoor experience. Here, a dynamometer bed is placed between microphones arranged in two rows, allowing noise to be analyzed as though a car is passing by. After extensive tests were done in this ambience and facility, AUDI took the e-tron models to the streets, where they did further testing.[iii]

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The Audi R8 e-tron on the acoustic test bed

The Nissan vehicle sound for pedestrians (VSP) system, installed on their Leaf electric vehicles, is another one worth considering. While creating their VSP system to increase pedestrian safety, Nissan sought to understand sonic interactions and the fashion by which the human ear responds to sounds in different environments. Their goal was to be able to address issues such as human sensitivity to different frequencies, hearing loss and the ageing, and the frequency of ambient noises.[iv]

As a result, Nissan tested various frequencies of sound including nine sample sounds from internal combustion engines. Sounds with high frequencies were found to be the most difficult to detect by pedestrians. Additionally, low frequency sounds were tested, and while they were found to be more detectable to pedestrians outside the vehicle, inside the vehicle the sound was unusually loud.

Nissan's solution is to use sound frequency with two peaks and one dip, resulting in sound levels detectable outside the vehicle by pedestrians, but barely detectable while inside the vehicle. More specifically, twin peaks of 0.6 kHz and 2.5 KHz and a dip of 1Khz were found to most ideal to both normal pedestrians as well as elderly pedestrians who are almost incapable of detecting sounds of high frequencies. The 0.6 kHz is very audible to the elderly while the 2.5 KHz is audible to people with healthy hearing capacities. The 1 KHz dip is used to counter the ambient sound which usually peaks at 1 KHz.

In order to develop these ideal frequency ranges, Nissan considered several issues. The first is frequency sensitivities in humans. Fundamentally, frequencies in the range of 2 Hz to 5 kilo Hz fall in the audible range of the human ear and this, due to ear canal resonance and the transfer function of middle ear ossicles. Thus, the range of frequency integrated in the VSP system falls within this bracket.

Also, the sensitivity of the human ear is reduced with consequent reduction in sound levels; i.e. sensitivity difference is starkly increased with reduction in sound levels. As a result, humans are able to hear loud sounds even though they come from long distances and are quite naturally, unable to hear feeble sounds even though coming from relatively short distances.

The second issue is hearing loss as a result of ageing. As humans age, the capability to hear high frequency sounds is significantly reduced, making it difficult to detect sounds with frequencies over 1 kHz. As a result, the VSP system has been implemented to accommodate technology that allows for sounds ranges whose peak is below 1 kHz.

Finally, Nissan took the frequency of ambient noises into consideration when designing their VSP system. The frequency of sound on a busy traffic day peaks at approximately around 1 kHz. Thus, in order for the sounds of an electric vehicle to be heard, the system should deliver a sound that peaks at somewhere close to 1 kHz. The VSP system has two peaks and one dip; it peaks twice at 0.6 kHz and 2.5 kHz and dips at 1 kHz. Both peaks have their own advantage - the 2.5kHz is audible to the ordinary human ear while the 0.6kHz is audible to the elderly who are impervious to high frequency sounds.[v]

Nissan's VSP System therefore aims for the following:

- The sound produced is similar to that produced by any other vehicle driven by an internal combustion engine.
- The pitch of sound is commensurate to the speed of the vehicle.

- Sound produced during breaking is audible to pedestrians besides being quiet to neighborhoods and drivers of course.

That said, driver reviews of this new VSP system have not always been positive. One writer (Popular Mechanics) described the sound made by the VSP system as "chirps like a cyborg cricket."[vi]

Keeping Range Extenders Noisy by Holding Back on Innovations of Silence

Manufacturers are addressing many disadvantages of EVs and HEVs like these sounds issues with creative solutions, but they're also solving such problems by holding back on innovations. For instance, the range extender, that miniature engine that can power your EV for some extra miles, is being kept somewhat noisy in order to make the vehicles more noticeable to pedestrians.

Most range extender prototypes are powered by two cylinder engines, often derived from motorcycles so they usually produce acceptable noise. Given the need to produce some noise from EVs and HEVs, some manufactures are simply not working on minimizing the noise produced by range extenders. This is most likely to bring down the manufacturing cost of extenders as a complex noise reduction system can be one of the priciest parts of an EV.[vii]

Conclusion

Of course, sound isn't all about pedestrian safety. Many OEMs are also working with solution providers to develop a comprehensive approach to the sound experience the driver and passengers feel. Things such as extremely efficient and cost-efficient insulation, strategic sound designs, and more are all currently being developed at all levels of the automotive industry. By optimizing what noises enter the vehicle and what noises are added inside the cabin, manufacturers hope to provide a complete sound experience that makes driving an EV or HEV totally unique.

Nevertheless, there are mixed responses from the automobile industry to the proposed Pedestrian Safety Enhancement Act of 2010 as well as other international legislations, including some frustrations about the requirement to add noise to what most feel is an extremely positive perk of owning an EV or HEV: the silence. According to some of the car manufacturing giants in Detroit, adding artificial sounds to electric vehicles will make them louder than necessary and the cost involved is too much. Whether cities need to address safety issues on a larger scale or whether the OEMs will create their owns solutions to overcome these challenges remains to be seen.

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A student of all things green, Maryruth has a special interest in cleantech and green buildings. In recent years, Maryruth has worked as the senior editor of The Green Economy magazine, is a regular blogger for several green business ventures, and has contributed to the editorial content of not one, but two eco-living websites: www.ecolife.com and www.GreenYour.com. You can learn more about Maryruth's work by visiting her site, www.jadecreative.com.

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